Discussion of: “Using ‘Noise-Corrected OVT Fold’ to optimise land seismic acquisition risk, costs, and quality” (C. Stork, First Break, January 2023, 45-49)

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Introduction

Christof Stork is founder and Chief Scientist of Land seismic noise specialists. They claim “By using advanced algorithms for noise identification and removal we are changing noise removal on land seismic data from an art to a science.”

In my career I have not met many areas where noise was a real problem; if it looked as such, increasing fold virtually always helped (after having made sure that two of the four sampling intervals are sampled ‘adequately’, Baeten et al, 2000). A notable exception is (was?) Saudi Arabia, where severe karsting in the near surface produced nearly featureless shot gathers.

In the following I make some comments on Stork (2023). First I discuss the deviant use of ’Offset Vector Tiles’ in the paper. Next the example given of shot records with much noise is not representative according to my analysis. Then there is a discrepancy between modern day dense sampling and the main survey design serving as an example of the technique of noise-corrected fold. This is followed by a few words on ‘independent fold’ and some remarks about the conclusions.

Offset-vector tiles

The term offset-vector tile (OVT) was introduced by Vermeer (2001a, 2001b, 2010). Each OVT has the size of a unit cell which represents the periodicity in a regular geometry. In orthogonal geometry the size of the unit cell is determined by the shot- and receiver line intervals. Each OVT has its own range of offset vectors in inline and in crossline direction. Combining OVTs with the same offset vectors creates a singlefold tiling, i.e. an OVT gather, across the survey area. Such an OVT gather is the nearest one can get to a common offset gather which is the ideal minimal data set (MDS) covering the whole survey area. If the unit cell is not too large the spatial discontinuities in the OVT gathers do not lead to sizable migration artefacts when migrating those singlefold gathers. Lecerf et al (2009) shows a beautiful example of detecting azimuthal anisotropy using migrated OVT gathers.

Stork (2023) also uses the term OVT for offset vector tile. However, his definition of an OVT is rather different than the original one. In his terminology OVTs are subdivisions of bins, grouping all traces with a small range of offset vectors into sub bins. To avoid confusion with the original definition of OVT it would be better to call those subdivisions offset-vector bins (OVBs). It can be a useful concept when dealing with irregular geometries where subdivision of the data in OVT gathers cannot be achieved, if only because there is no unique unit cell in such a geometry. According to Stork (2023) OVBs can be used to determine an optimum irregular geometry taking into account noise conditions for the corresponding shots and receivers. Next, the design results will show to what extent the resulting noise-corrected OVB-fold is uniform.

Example of much noise (Figure 1)

Figure 1 in Stork (2023) shows a shot gather with 4 receiver lines. In the old days (and that’s when these data must have been acquired) narrow geometries with only 4 receiver lines in the template were the rule, also because the recording instruments could handle only a small number of channels. All 4 receiver lines must have two parts, because each group has two separate shortest offsets. A plausible explanation for this overlap is that they reached the edge of the survey area, whereas not all available channels had been used. So, in order not to waste precious channel capacity, four extra pieces of line were laid out just along the end of each receiver line, all on the same side, see Figure 1. This method also helped to increase fold in the fold taper zone. Figure 1 does not give a scale of the configuration, although it may have been recorded with 96-channel instruments and with receiver locations spaced at 220 feet, a common selection in the USA in the old days.

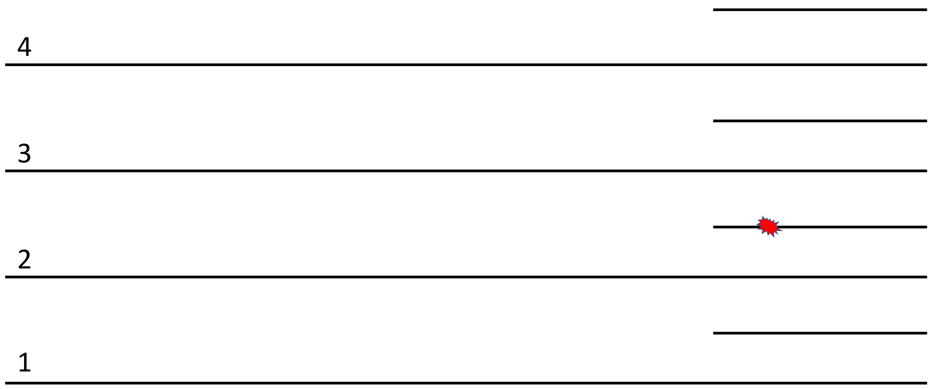

Figure 1 Approximate configuration of shot gather in Figure 1 of Stork (2023). Spare receiver positions were located at the end of the survey area about halfway the existing receiver lines. The location of the shot is pretty close to the second inserted receiver line. Scales are not available.

The noise varies dramatically at a small scale (20 – 100 m) according to the caption in Stork (2023), but the reader cannot verify this as the axes are not annotated. What is visible is the dominance of subhorizontal ground roll. Most likely these data have been acquired with long field arrays that killed all steep events. Therefore, the short-length noise is caused by poor acquisition parameters rather than by difficult near-surface conditions. Without the field arrays and with a smaller sampling interval there would have been much more continuity in these data.

My question is; why are 40-year old data used as an example to illustrate modern-day noise problems?

Different noise types and example application

The author explains (at a late stage) that “Our consideration of noise in this article refers to noise that cannot be removed using predictive or filtering techniques in processing.” The correct justification for this approach is that “recent acquisition today is dense enough that these requirements (for successful filtering techniques, GV) are often easily met.”

Next, it is highly surprising that the main implementation example of the noise-corrected technique is about a survey with 25 x 25 m bins. This means that the shot and receiver sampling intervals are in the order of 50 m (assuming densely sampled shot and receiver lines continue to be used in a random geometry in order to benefit from filtering techniques to remove shot-generated noise). In all areas that I know this kind of sampling is not dense enough and does not allow removing all shot-generated noise with filtering techniques. In particular all ground roll will be heavily aliased and difficult to be removed completely.

The author claims that the irregular shot layout of Figure 8 ‘produces a uniform Noise-corrected OVB (well, OVT) fold’. That is what his paper is about. Yet, it is a big shortcoming that not any such result is shown. Of course, one cannot expect that in an 8 x 8 subdivision of the bins all results can be shown, but at least a few would have been essential. Moreover, a source layout is only part of the solution. The corresponding receiver layout is equally important and would have been of interest as well.

The author uses a zigzag layout to increase the shot density in a difficult area. Some irregularity always occurs in the shot layout. However, splitting a shot line into two or three parallel lines would maintain continuity and be helpful in removal of shot-generated noise.

Independent fold

According to the author placing two sources too close to each other would reduce 'independent fold'. This is a typical rule from the old days when 3D surveys had low fold and designers only looked at absolute offset and not at azimuth, or at the offset vector. If absolute offset is the same but azimuth is different there is no redundancy. Yet, one might say that repeating a shot in the same location could be redundant. It may be, but if the problem is too weak a source or too strong ambient noise, then repeating a shot several times can be very helpful. See Cambois (2002) for a beautiful example. The danger for shots to get too close to each other in a geometry with 25 x 25-m bins is pretty small anyway.

Conclusions

Stork's paper introduces the interesting concept of using an automated survey design taking into account local variations in shot- and receiver-noise conditions. The criterion for success is to get a uniform noise-corrected fold across the survey area in a chosen number of offset-vector bin gathers. Unfortunately, the idea is not illustrated with a clear example that the OVB noise-corrected fold produces the desired uniform fold. What is even more regrettable is that the idea is applied to an existing 25 x 25 m bin geometry. This starting point for survey design does not meet present-day standards of sufficiently dense sampling. Note as well that getting uniform OVB-fold for a large binsize is much easier than for a small binsize.

The conclusions at the end of the paper ('we can significantly reduce costs and improve quality'; 'this process will take some additional effort and skill, but it is worth it') provide an optimistic assessment of potential benefits that as yet have to be demonstrated.

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On LinkedIn, Christof Stork commented to my discussion note with the following:

As I mentioned in our email exchange 4 weeks ago, your comments have some errors. And I think you have a simplistic view that land seismic noise is coherent and cooperative. There is much to be gained from taking a broader view of land seismic noise.

My reply:

Thanks, Christof, for reacting to my post. With 'errors' you probably refer to my discussion of Figure 1 and of binsize as mentioned in your example of Figure 8.

Your Figure 1 is meant to illustrate the dramatic variation of noise over a short distance. Unfortunately, Figure 1 does not show any scales and the acquisition parameters are not specified. In a paper on acquisition techniques it is really helpful to provide such specifications. Now I had to speculate on those parameters and concluded that the data reminded me of the old days in the eighties when long field arrays and coarse sampling were the rule. You mentioned in your email that the data were actually acquired in 2010, but you did not yet disclose the parameters. My reconstruction of the geometry suggests that 8 receiver lines were used rather than 4 and this implies that there is a large spatial discontinuity in each of the four groups of traces in Figure 1.

Figure 8 is about the example geometry characterized by a fold of 3500 in 25 x 25 m bins. In my discussion I linked this binsize to 50-m shot and receiver station intervals, which is not correct for random geometries. The binsize can be selected in the processing stage. What I meant to say is 1) that this binsize is also something of the past, nowadays binsizes in the order of 6.25 x 6.25 m are not uncommon anymore allowing better processing and better interpretation, and 2) even in random geometries it's helpful to have two spatial coordinates that are sampled more densely than the other two spatial coordinates, because this allows better removal of shot-generated noise (in cross-spreads or in 3D common shot or receiver gathers) and a small final binsize.

You also think I have a simplistic view of noise. I do not quite concur with this diagnosis.